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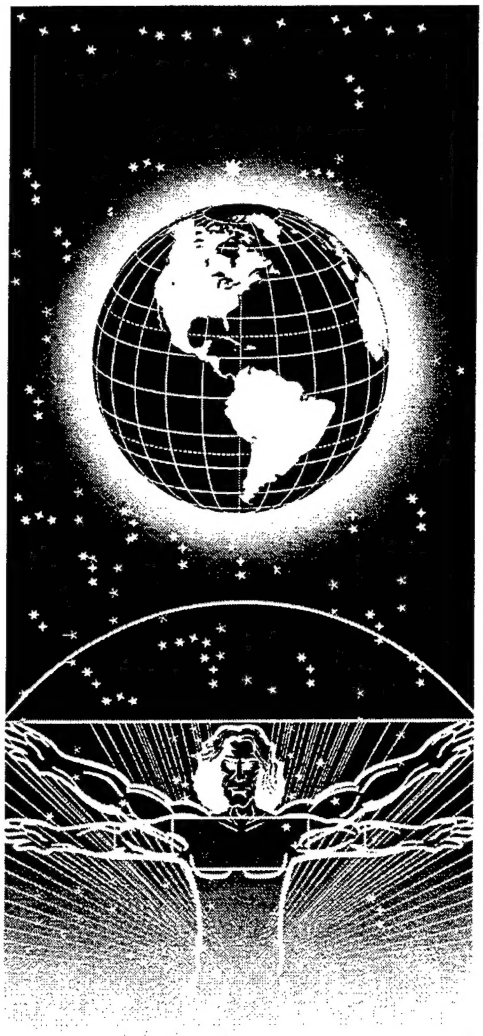

UNITED STATES AIR FORCE
ARMSTRONG LABORATORY

INVALID CYCLE ERGOMETRY ASSESSMENT OUTCOMES AT FIVE AIR FORCE BASES

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The Office of Public Affairs has reviewed this technical report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This technical report has been reviewed and is approved for publication.

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13. ABSTRACT *(Maximum 200 words)*

"Invalid" outcomes of the US Air Force's (AF) cycle ergometry assessment were analyzed from data collected at five AF bases. An AF member can receive one of three results from the assessment: Pass, Fail, or Invalid. Analysis revealed that 1548 of 9437 tests resulted in an Invalid outcome (16.4%; 74.0% passed, 9.6% failed). Excessive heart rate (HR; >85% of predicted HR maximum) accounted for most (39.7%) of the Invalid outcomes. It was assumed that the high HR responses were due to too high of a workload (WL). The current software logic prompts a 0.5 or 1.0 kilopond (Kp) increase (or no increase) in resistance, depending on HR response to the WL progression phase of the assessment (minutes 3, 4 and 5). We hypothesized that by lowering the HR range required for an increase in the WL, the HR may stay below 85% of predicted maximum, and allow a score to be assessed. Even though Invalid results due to excessive HR comprise the greatest percentage of Invalid assessments, it was predicted that a 10-beats per minute adjustment in minutes 3 and 4 would potentially reduce the Invalid rate at most by 3.6%, to 12.8% of all assessments.

14. SUBJECT TERMS

Cycle ergometry, US Air Force, invalid test results, fitness assessment

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FIGURES

TABLES

SUMMARY

The purposes of this study were 1) to determine the Pass, Fail, and Invalid rates of the Air Force (AF) cycle ergometry (CE) assessment, and 2) to analyze the potential impact of a 10 beats per minute (bpm) reduction of the heart rate parameters during minutes 3 and 4 of the assessment. Data for the study were collected from five Air Force Bases: Brooks AFB, Kelly AFB, Lackland AFB, and Randolph AFB in Texas, and Patrick AFB in Florida.

The CE assessment consists of cycling at 50 revolutions per minute (rpm) against sub-maximal resistance levels for a period of 8 - 12 minutes. The test involves a two-minute warmup, 0 - 3 minutes of workload (WL) progression, and 6 - 7 minutes of steady-state, sub-maximal exercise. This is followed by a cool-down period, until the heart rate decreases to 110 bpm or less.

An AF member can receive one of three results from the fitness assessment: Pass, Fail, or Invalid. An Invalid outcome is assessed when 1) the heart rate (HR) response falls outside the parameters set forth for the assessment (i.e., HR too high, or HR below 125 bpm), 2) the subject requests termination of the assessment, or 3) an error occurs due to either equipment failure or assessment administrator error. Originally, there were seven possible Invalid Category outcomes:

1) HR exceeds 85% of maximum (HRm; based on 220 minus age)
2) HR does not reach 125 bpm in the last minute of the assessment
3) HR varied more than 3 bpm in the final 2 minutes
4) Subject could not maintain 50 rpm on the cycle
5) Rating of Perceived Exertion (RPE) exceeds 15
6) Subject requested termination of the assessment
7) Other

Category 5 (RPE exceeds 15) was deleted in April 1996.

Data from all five bases revealed that 1548 of 9437 assessments resulted in an Invalid outcome (≈16.4%). The rate at which AF members received a Pass was ≈74.0%, while the rate at which they received a Fail was ≈9.6%. Approximations of the three outcome rates are given because, for this evaluation, re-tests by the same subject are included and the total number of assessments is therefore inflated, versus total subjects assessed. Category 1 Invalids accounted for most Invalid assessments (615 of 1548; 39.7%). The next most frequently observed Invalid categories were Category 7 at 26.5%, and Category 3 at 15.1%.

Category 1 Invalids were of particular interest, because this group presented the greatest prospect for reducing the total Invalid rate through conservative reductions in the workload. It was presumed that a change in the HR-WL logic of the software (making it more difficult to receive an increase in WL based on HR) would provide the greatest impact or reduction in Invalid rates. Further analysis of the Invalid data, which was limited to Brooks, Kelly, and Randolph AFBs (n = 279), showed that:

- in 49.8%, 81.1%, and 72.5% of assessments, there was no increase in workload whatsoever at minutes 3, 4, or 5, respectively. This suggests that a projected adjustment to the HR-WL software logic would have a more confined impact on the Category 1 outcomes.
- of all assessments that resulted in a Category 1 Invalid and that involved a workload progression, a maximum of 38.1% in minute 3 and 17.4% in minute 4 could benefit from a conservative reduction in the HR-WL criteria (by 10 bpm) at minutes 3 and 4 (i.e., a lower HR response is needed to qualify for a workload increase).
- the maximum projected impact for the proposed change in the HR-WL logic (a 10 bpm adjustment at minutes 3 and 4) would be a 3.6% reduction in the total number of Invalid assessments AF wide, thus reducing the total number of Invalid assessments from 16.4% to 12.8%, at most.

As noted, a reduction in Category 1 Invalid outcomes is less than anticipated. Even though this category is the single largest contributor to the Invalid outcomes, this finding suggests that any adjustment in the current workload progression logic would have limited potential for reducing the total number of Invalid assessments. Other factors, such as low fitness levels, HR variability, and tester error, also contribute heavily to the undesirably high frequency of Invalid outcomes and should seriously be addressed.

INTRODUCTION

The need to accurately evaluate the fitness level of the Air Force (AF) population has been addressed with a submaximal cycle ergometry (CE) assessment. For a submaximal assessment to predict maximal oxygen consumption ($VO_{2\,max}$), there must be an interval during which the heart rate (HR) is assessed at steady state. The HR range for the AF CE assessment during this interval is from a minimum of 125 beats per minute (bpm), to a maximum of 85% of HR maximum (HRm), which is calculated as 220 minus the individual's age times .85. If an individual's HR response falls outside of this range, $VO_{2\,max}$ may not be as accurately predicted. The possible outcomes of the AF fitness assessment are Pass, Fail, or Invalid. When an individual's HR response falls outside of the designated range, the assessment is categorized as an Invalid. At present, the CE assessment too often results in an Invalid assessment, specifically Category 1 (high HR), and no "score" is assessed. The subject must then be re-tested on a subsequent day.

Excessive Invalid assessments, and the resulting need for a re-assessment, present an unwanted drain on manpower and resources, as well as morale. Anecdotal evidence from fitness assessment personnel first suggested that a majority of Invalid assessments were due to subjects exceeding 85% HRm (Category 1 Invalid). This evidence is in concert with some findings from earlier independent studies that validated the CE assessment. It was postulated that those subjects who received a Category 1 Invalid outcome may have the greatest potential to instead receive a score (Pass or Fail) after an adjustment to the workload progression portion of the CE protocol. Therefore, this study has two purposes: 1) to determine the rates of Pass, Fail, and, especially, all categories of Invalid assessment outcomes, and 2) to analyze the impact on the outcome (i.e., a Pass, Fail, or Invalid) of a 10 bpm reduction of the heart rate parameters (which determine the workload progression portion of the evaluation) during minutes 3 and 4.

A follow-up study will compare the current assessment protocol to two proposed protocols in an attempt to reduce the overall number of Invalid assessments. The two protocols have been designated Protocols A and B (see Appendix A). Protocol A would alter the computer logic to make it more difficult for a subject to receive a 1.0 kilopond (Kp) or 0.5 Kp workload progression (i.e., lower the minimum HR needed to receive a workload increase; see Appendix B, Table B4). Protocol B would lengthen each of the three stages at which workload progression occurs by 1 minute, thereby allowing more time to achieve a steady state HR. See Appendix A for Protocols A and B; only the potential impact of Protocol A will be discussed further in this report.

METHODS

Available information on fiscal year 1996 AF submaximal CE assessments from five bases was collected and analyzed. For this initial evaluation, data are based on the number of total assessments, with special interest in service members who received Category 1 Invalid outcomes. These numbers include the same individuals who took repeat assessments. All results are calculated from the combined male and female data, unless otherwise noted.

Total assessments (all Pass, Fail, Invalid and re-tests) from Brooks AFB (n=530), Kelly AFB (n=2118), Lackland AFB (n=2191), Patrick AFB (n=2363), and Randolph AFB (n=2235) were sorted and the Pass, Fail, and Invalid rates were determined. These five bases were selected primarily because of convenient geographical access to the databases. Patrick AFB was specifically included because it employs AeroForce 2000 software.

Frequencies for the seven categories of Invalid outcomes were also calculated. The seven categories were delineated by the following:

1) HR exceeds 85% of maximum (HRm; based on 220 minus age)
2) HR does not reach 125 beats per minute (bpm) in the last minute of the assessment
3) HR varied more than 3 bpm in the final 2 minutes
4) Subject could not maintain 50 revolutions per minute (rpm)
5) Rating of Perceived Exertion (RPE) exceeds 15
6) Subject requested termination of the assessment
7) Other

Category 5 (RPE exceeds 15) was deleted in April of 1996.

Combined Category 1 Invalid assessment data from Brooks, Kelly, and Randolph AFBs were compiled and further analyzed by HR response and workload (WL) progression during minutes 3, 4, and 5 (see Tables 2-5). Individual Invalid data from Brooks, Kelly, and Randolph AFBs are provided in the tables of Appendixes D-G. Due to the large time investment necessary to analyze the data in this manner, these analyses were not done for Lackland or Patrick AFBs. However, assessment records for selected individuals from 12 other AF bases who had three Invalid outcomes were analyzed. These data were separated by Invalid category and only the Category 1 Invalid assessments were used for separate analyses. These service members' WL progressions and HR responses during minutes 3, 4, and 5 were also determined (see Table 6).

Re-test data from the five bases were also examined. For this analysis, assessments were separated by subject number, so that the total number of subjects could be differentiated from the total number of assessments.

Subject data were downloaded from the FitSoft 2.0 cycle ergometry software database at four of the bases. The fifth base, Patrick, uses AF 2000 software (Microfit, Inc.). Protocols and algorithms for FitSoft 2.0 and AF 2000 are the same, regardless of the software. All data were transferred to and sorted on Microsoft Access software. Further analysis was performed with Microsoft Excel 5.0 software.

RESULTS

Overall Analysis of Invalid Assessments

Invalid assessment outcomes from the five bases accounted for ≈16.4% of all assessments (n=1548 of 9437), while the percentage receiving a Pass was ≈74.0%(n=6985 of 9437), and the percentage receiving a Fail was ≈9.6% (n=904 of 9437; see Figure 1, Table 1). The breakdown of Invalid assessments, by category, as a function of the total number of assessments evaluated was: Category 1, 6.5% of all assessments; Category 2, 1.3%; Category 3, 2.5%; Category 4, 0.08%; Category 5, 1.5% (this category was deleted in April 1996); Category 6, 0.3%; and Category 7, 4.3% (see Table 1). Again, repeat test outcomes were not discriminated here. See the Methods section of this report for category descriptions.

Analyses of only initial assessment outcomes from Brooks, Kelly, and Randolph AFBs were completed, in order to determine if the analysis of *total* combined assessment data was a reasonable approximation of what occurred on the initial evaluation. Invalid assessment outcomes from the three bases accounted for 16.2% of all assessments (n=660 of 4070), while the percentage receiving a Pass was 75.8%(n=3086 of 4070), and the percentage receiving a Fail was 8.0% (n=324 of 4070; see Table 1A). The breakdown of Invalid assessments, by category, as a function of the total number of assessments evaluated was: Category 1, 6.4% of all assessments; Category 2, 0.5%; Category 3, 1.9%, Category 4, 0.05%; Category 5, 2.3% (this category was deleted in April 1996); Category 6, 0.2%; and Category 7, 4.9% (see Table 1A). See the Methods section of this report for category descriptions.

Category 1 Invalid Assessments

Combined Category 1 Invalid data from Brooks, Kelly, and Randolph AFBs were examined by 1) minute of assessment (n=279 for minute 3, n= 264 for minute 4, and n=255 for minute 5) and 2) workload progression (see Tables 2, 3, and 4). The number of assessments in each minute declines due to the early termination of some assessments, generally because of subjects' HR being greater than 85% of predicted maximum. Category 1 Invalid assessments were reviewed in detail at these bases, because the data suggest that changes to the current protocol that impact this category should reduce the greatest number of Invalid assessments (see Figure 1). Table 2 shows that 49.8% of these assessments did not receive a workload increase in minute 3. The frequency of receiving no WL progression increases dramatically in minutes 4 and 5

(81.1% and 72.5%, respectively; see Tables 3 and 4). Overall, at roughly 67.4% of the 798 decision points (points during the assessment when a WL progression could occur, or minutes 3, 4, and 5), no WL increase was indicated.

The Invalid assessments from Brooks, Kelly, and Randolph AFB (n=279) were further categorized by the magnitude of the HR response, relative to the WL increases during minutes 3, 4, and 5 (Table 5). This breakdown was completed in order to estimate the potential impact of making the WL progression criteria more conservative (lowering the HR range to make it more difficult to receive a WL progression). Due to the excessive time needed for the analyses, it was not determined whether those who received a WL progression in minute 3 also received a WL progression in minute 4 and/or minute 5, or vice versa. Results reported here are based on total assessment data, and not on individual responses (i.e., the subject is counted as many times as they were re-assessed).

MULTIPLE INVALID ASSESSMENTS

Any AF member who receives an Invalid outcome must re-take the assessment. Data from the five bases revealed that of subjects who receive a Category 1, 2, 3, 4, or 6 Invalid outcome on their first assessment, 55.8% (n=280) Pass on their first re-test, 22.1% (n=111) Fail on their first re-test, and only 22.1% (n=111) have a second Invalid result (Table 6). Category 5 and Category 7 Invalid assessments were excluded from the analysis. Category 5 was deleted as an option in April 1996. Category 7 is not indicative of subject response, but rather is due to equipment or Fitness Assessment Monitor (FAM) error. Thus, to more accurately evaluate the potential impact of Protocol A (lowering the minimum HR needed to receive a workload increase), only Invalid categories that are directly caused by or related to the protocol were included in the analysis of re-tests.

Of the 111 individuals with an Invalid outcome on their first re-test, 70 completed their second re-test with the following results: 44.3% (n=31) received a Pass, 20.0% (n=14) received a Fail, and 35.7% (n=25) had a third Invalid assessment. These numbers are only for re-tests after an Invalid, and do not include re-tests after a Fail on the initial assessment or first re-test.

A smaller database consisting of individuals with three or more Invalid assessments was also used to evaluate the HR response to minutes 3, 4, and 5 of the assessment. The records for 46 subjects were evaluated and it was determined that of 138 assessments, 59 were identified as Category 1 Invalid (see Table 7). It was not possible to distinguish between the annual assessment, first re-test, or the second re-test for this data. The data show that 76.3%, 94.8%, and 86.0% of these assessments had no workload progression at minutes 3, 4, and 5, respectively. Of the original 59 Invalid assessments, one assessment was terminated before minute 4, and eight were terminated before minute 5. These numbers correspond to a total of 167 decision points. At 143 of these points (85.6%), no workload progression occurred.

DISCUSSION

IMPACT OF PROTOCOL A

Earlier validation research had suggested that the current AF CE protocol would produce a relatively high rate of overall Invalid test outcomes. This study was primarily undertaken because of the perceived high incidence of Invalid fitness assessments due to HR above the accepted range (>85% HRm; Category 1 Invalid). Our analysis of available data has shown that Category 1 Invalid assessments account for only 6.5% of all assessments at the five bases studied (n=9437; see Table 1). Category 1 Invalid assessment outcomes (n=615) account for 39.7% of all Invalid assessments (see Table 1, Figure 1). In other words, even though the percentage of total assessments accounted for by a Category 1 Invalid outcome is lower than expected, the percentage of Category 1 Invalid assessments among Invalid outcomes is still considerable. The impact of a modified protocol on reducing Invalid outcomes will, therefore, be lower than desired. Even so, Protocol A may affect the largest single group of Invalids and, therefore, have a substantial impact on reducing the total number of Invalid assessments. This protocol change could possibly have some impact on Categories 2-4 and 6, as well. It is speculated that lowering the HR range needed to elicit an increase in WL may increase Category 2 Invalids, but may decrease the number of Category 3, 4, and 6 Invalid outcomes.

Protocol A is designed to affect the workload progression by making it more difficult for a subject to receive an increase in workload. For example, a 33 year old subject with a HR of 102 bpm at minute 3 in the current AF protocol would receive a 1 Kp progression. Under Protocol A, this individual would receive a .5 Kp workload progression (see Appendix B for HR criteria), thereby keeping the HR lower. It is estimated that Protocol A could reduce the number of Category 1 Invalids outcomes by only 55.5% at the very best (38.1% of assessments possibly affected in minute 3, plus 17.4% of assessments possibly affected in minute 4; see Table 5). Therefore, Protocol A could reduce the total number of Category 1 Invalid assessments from 39.7% to 22.7% (from Tables 1 and 5: [(615-341)/(1548-341)](100)=22.7%). A reduction in Category 1 Invalid assessments from 39.7% to 22.7% could reduce the percentage of total Invalid assessments from 16.4% to 12.8%, thus potentially lowering the total number of Invalid assessments by 341, or 3.6%.

NOTE: Generally speaking, this approach to estimating the potential for reducing Invalid outcomes has limitations. The physiological response in subsequent minutes after a workload adjustment cannot normally be predicted. Also, multiple assessments (re-tests) by the same subject could not be differentiated. Consequently, the predictions presented here are based on the *total* number of assessments; that is, without correction for the possible re-testing of subjects. Therefore, an individual receiving a workload progression in both minutes 3 and 4 is evaluated as two assessments. This could easily lead to overestimation of the impact of Protocol A on the rate of Invalid outcomes.

Evaluation of the initial assessment data (n=4070) from Brooks, Kelly, and Randolph AFBs, excluding Categories 5 and 7, indicated that 90.2% of these assessments received a score, while 9.8% had an invalid outcome (see Table 1A). This percentage was determined by subtracting Category 5 and 7 assessments (n=291) from the total number of Invalid assessments, and the number of total assessments (i.e., 660 minus 291, and 4070 minus 291, respectively). Individuals with an initial Invalid assessment, excluding Categories 5 and 7, received a score on the first re-test at the rate of 77.9% (see Table 7). Therefore, 97.8% of all subjects receive a score within the first two assessments.

WORKLOAD PROGRESSION

Analysis of 279 Category 1 Invalid assessments (from Brooks AFB, Kelly AFB, and Randolph AFB) showed that only 50.2%, 18.9%, and 27.5% of assessments had a workload progression at minutes 3, 4, and 5, respectively (see Tables 2, 3, and 4). In comparison, the data for subjects with three Invalid assessments (see Table 6) show that only 23.7%, 5.2%, and 14.0% of assessments had a workload progression at minutes 3, 4, and/or 5, respectively. This indicates a majority of subjects who receive an Invalid score are riding at or near the initial workload for the entire assessment (see Appendix B, Tables B1 and B2). The initial workload is based on gender, age, weight, and self-reported activity level. While it is possible some individuals could receive a Pass without an increase in workload, the score would probably indicate that they are in the lowest range of passing scores. As is shown in Table 7, 55.8% of first re-tests result in a Pass, while 22.1% result in a Fail. This would indicate that while a preponderance of those who receive an initial Invalid outcome can pass the assessment, it is generally only after the software initiates a lower WL, allowing the heart rate to stay lower, that they are able to pass (i.e., they are more unfit, since it requires a lower WL to keep their HR below the upper limit). Since the Fail rate is twice as high in this re-test group, compared to the initial assessment outcomes, it appears that the first Invalid outcome is often masking what should be categorized as a Fail.

CATEGORY 7 INVALIDS

The second largest Invalid category was Category 7 ("Other"). Data from Brooks, Kelly, Randolph, Lackland, and Patrick AFBs demonstrate that Category 7 Invalids make up 26.5% of all Invalid assessments, and 4.3% of total assessments (see Table 1). Category 7 normally indicates FAM error and, in very few cases, equipment error. It may be noteworthy that Patrick AFB, which employs the more "automated" CE assessment software/hardware system (AeroForce 2000), had the lowest Category 7 Invalid test rate (see Appendix C).

Most of the software problems specific to the assessment have been identified and corrected in the newest version of FitSoft (FitSoft 2.0). Yet computer and equipment failures will continue to happen intermittently. HR monitors may "fail" when the battery runs low, when the monitor is not properly placed during subject preparation, or when the transmitter is too far away from the watch during the assessment. Tester error can include improper HR monitor operation or placement, as well as inaccurate

data entry or work-load setting. More thorough training in CE, and knowledge of the typical responses to exercise may reduce the incidence of Category 7 Invalid outcomes by the FAM. Prompt, accurate WL adjustments and vigilant WL monitoring by the FAM cannot be emphasized enough.

Other factors, such as scale calibration (body weight), maintaining higher or lower than 50 rpm, conversation between the subject and FAM during the assessment, self-reported activity level, fan availability, and room temperature have an undetermined, but possible, impact on the assessment, and may contribute to the high Invalid rate.

However, other modest protocol adjustments to the computer logic, such as improving the sensitivity of the HR variability criteria, and re-describing as Failures those Category 1, 3, 4, and 6 Invalid outcomes that occur at WL too low to achieve a passing score, may offer the most fruitful and pragmatic approach to further reducing the rate of repeated Invalid assessment outcomes.

CONCLUSIONS

This study has proven to be valuable for the following reasons:

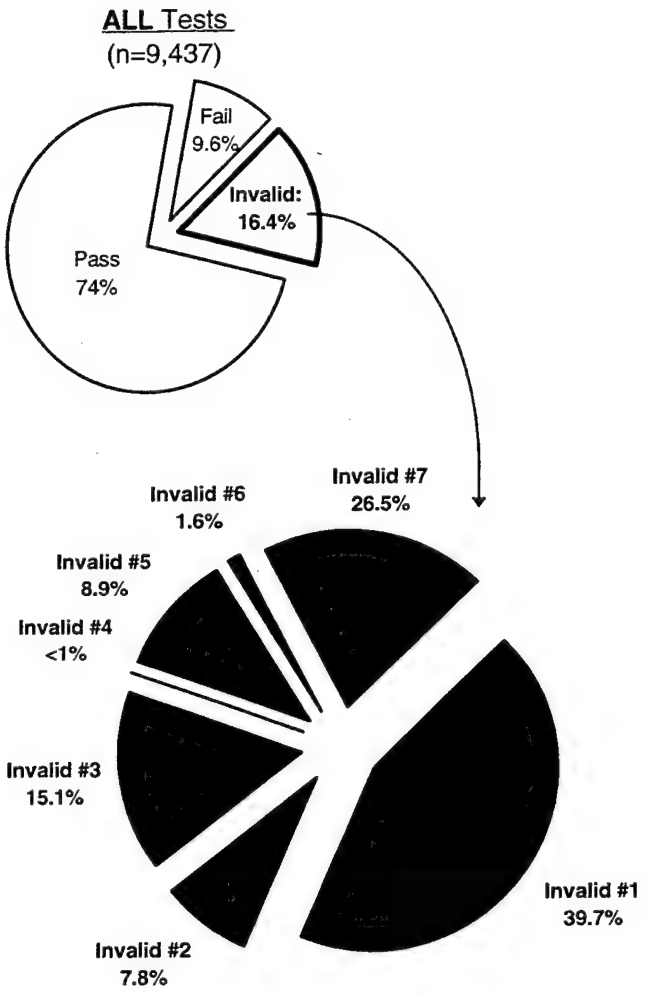
- We have shown that the majority of Invalid assessments are not due to high heart rates, as first hypothesized, although Category 1 does make up the largest share of Invalid outcomes.
- A reduction of 10 beats per minute (Protocol A) may impact the greatest number of Category 1 Invalid assessments (see Table 5), although it is likely a relatively small number (n=341).
- Excluding Invalid Category 5 and 7 outcomes, 90.2% of all assessments result in a valid score. Following re-assessment, this percentage increases to 97.8%. It appears Protocol A could further increase this percentage.

The number of subjects who receive a score could be increased further by reducing the occurrence of other Invalid Categories, Category 7 in particular. Category 7 Invalids can be reduced through proper attention and adherence to protocol, and knowledge of the testing procedures and subject responses.

The impact of more conservative WL adjustments should favorably affect the number of Category 3, 4, and, 6, as well as Category 1, Invalid outcomes.

Finally, modest protocol changes to the logic of the computer (i.e., HR variability criteria, minimum passing WL criteria, etc.) should be further investigated.

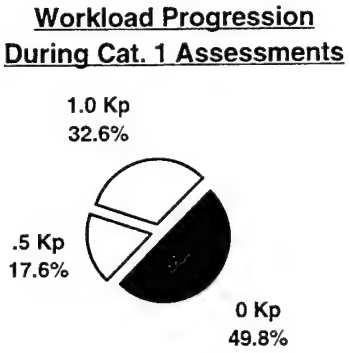
FIGURES



Invalid Category Legend:
Category 1 - HR exceeds 85% of maximum (based on 220 minus age)
Category 2 - HR does not exceed 125 bpm during the last minute of the assessment
Category 3 - HR varied more than 3 bpm in the final 2 minutes
Category 4 - Subject could not maintain 50 rpm
Category 5 - RPE exceeds 15 (deleted as a category in April 1996)
Category 6 - Subject requested termination of the assessment
Category 7 - Other

Figure 1: All tests - results by percentage
(five bases: Brooks, Kelly, Lackland, Patrick, and Randolph AFBs)

Minute Three:



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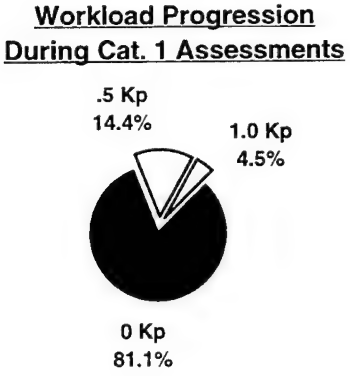
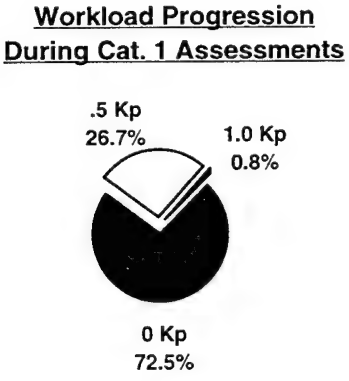


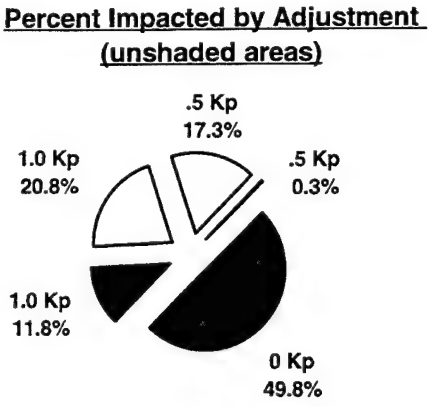
Minute Five:



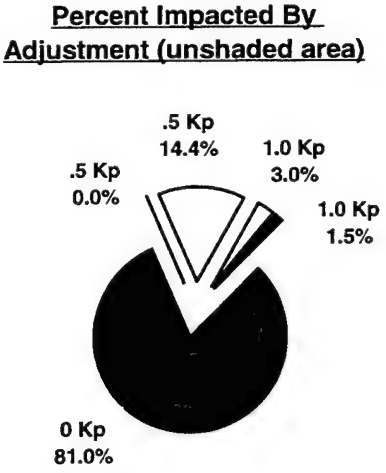
Legend: Unshaded areas = those who receive a WL increase.

Figure 2: Category 1 Invalid breakdown by minutes 3, 4, and 5 (three bases: Brooks, Kelly, and Randolph AFBs [n=279])

Minute Three:



Minute Four:



Minute Five:
No adjustment will be made to minute five.

Legend: Unshaded areas = those impacted by 10 bpm Protocol adjustment.

Best Projected Impact:

- It is estimated that, at best, 55.5% of the Category 1 Invalid assessments can be affected (38.1% plus 17.4% of Invalid assessments in minutes 3 and 4 from above).
- Category 1 Invalid assessments could be reduced to 22.7% of total Invalid assessments. This would reduce the number of Invalid assessments to 12.8% of all assessments taken.

Figure 3: Projected impact on Category 1 Invalid tests after a 10 beat per minute HR criteria adjustment (n=279)

TABLES

Table 1: Brooks, Kelly, Lackland, Patrick, and Randolph AFBs combined cycle ergometry assessment breakdown

Brooks, Kelly, Lackland, Patrick, and Randolph AFB Combined Assessment Results			
Test Result	**# of assessments**	**% of Total Tests**	
Invalids	**1548**	**16.4**	
Fail	**904**	**9.6**	
Pass	**6985**	**74.0**	
Total:	**9437**		
Test Result	**# of assessments**	**% of Total Invalids**	**% of Total Tests**
Invalid #1	**615**	**39.7**	**6.5**
Invalid #2	121	7.8	1.3
Invalid #3	233	**15.1**	**2.5**
Invalid #4	8	0.5	0.08
Invalid #5	137	8.9	1.5
Invalid #6	24	1.6	0.3
Invalid #7	410	**26.5**	**4.3**
Totals:	**1548**		

Table 1A: Brooks, Kelly, and Randolph AFBs combined initial cycle ergometry assessment breakdown

Brooks, Kelly, and Randolph AFB Combined Assessment Results			
Test Result	**# of assessments**	**% of Total Tests**	
Invalids	**660**	**16.2**	
Fail	**324**	**8.0**	
Pass	**3086**	**75.8**	
Total:	**4070**		
Test Result	**# of assessments**	**% of Total Invalids**	**% of Total Tests**
Invalid #1	260	39.4	**6.4**
Invalid #2	21	3.2	0.5
Invalid #3	79	**12.0**	**1.9**
Invalid #4	2	0.3	0.05
Invalid #5	93	14.1	2.3
Invalid #6	7	1.1	0.2
Invalid #7	198	**30.0**	**4.9**
Totals:	**660**		

Table 2: Brooks, Kelly, and Randolph AFBs minute three workload progression of Category 1 Invalid assessments

	Brooks, Kelly, and Randolph AFBs					
	Females		Males		Males and Females	
workload progression	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	14	20.9	77	36.3	91	**32.6**
.5 Kp	14	20.9	35	16.5	49	**17.6**
0 Kp	39	58.2	100	47.2	139	**49.8**
Total	67		212		**279**	

Table 3: Brooks, Kelly, and Randolph AFBs minute four workload progression of Category 1 Invalid assessments

	Brooks, Kelly, and Randolph AFBs					
	Females		Males		Males and Females	
workload progression	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	1	1.6	11	5.5	12	**4.5**
.5 Kp	4	6.3	34	17	38	**14.4**
0 Kp	59	92.2	155	77.5	214	**81.1**
Total	64		200		**264**	

Table 4: Brooks, Kelly, and Randolph AFBs minute five workload progression of Category 1 Invalid assessments

	Brooks, Kelly, and Randolph AFBs					
	Females		Males		Males and Females	
workload progression	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	2	1	2	**0.8**
.5 Kp	8	13.1	60	30.9	68	**26.7**
0 Kp	53	86.9	132	68	185	**72.5**
Total	61		194		**255**	

Table 5: Brooks, Kelly, and Randolph AFBs Category 1 Invalid heart rate response during CE assessment

Brooks, Kelly, and Randolph AFB							
		Minute 3		Minute 4		Minute 5	
workload progression (WLP)	beats below initial workload inc.	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	**1-5**	**34**	**12.2**	**6**	**2.3**	**1**	**0.3**
	6-10	**24**	**8.6**	**2**	**0.7**	**1**	**0.3**
	>10	33	11.8	4	1.5	0	
.5 Kp	**1-5**	**18**	**6.5**	**9**	**3.4**	**1**	**0.3**
	6-10	**30**	**10.8**	**29**	**11**	**6**	**2.4**
	>10	1	0.3	0		61	23.9
	beats above lower limit of WLP*						
0 Kp	1-5	7	2.5	25	9.5	14	5.5
	6-10	11	3.9	28	10.6	21	8.2
	11-15	9	3.2	27	10.2	26	10.2
	16-20	18	6.5	13	4.9	24	9.4
	>20	94	33.7	121	45.8	100	39.2
Total		**279**		**264**		**255**	

* Note: Lower limit of workload progression (i.e., highest HR at which an individual can receive a .5 Kp WL progression) determined by age and minute of progression (see Appendix B, Table B3).

Table 6: First and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Brooks, Kelly, Lackland, Patrick, and Randolph AFBs			
First Re-Test	**result**	**# of subjects**	**% of total assessments**
	Pass	**280**	**55.8**
	Fail	**111**	**22.1**
	Invalid	**111**	**22.1**
	Total	**502**	
Second Re-Test	Pass	**31**	**44.3**
	Fail	**14**	**20.0**
	Invalid	**25**	**35.7**
	Total	**70**	

Table 7: Heart rate response during CE assessment of 46 individuals with three Category 1 Invalid assessments

Males and Females Combined							
		Minute 3		**Minute 4**		**Minute 5**	
workload progression (WLP)	**beats below initial workload inc.**	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	1-5	4	6.8	0		0	
	6-10	2	3.4	1	1.7	0	
	>10	2	3.4	0		0	
.5 Kp	1-5	3	5.1	0		0	
	6-10	3	5.1	2	3.4	1	2
	>10	0		0		6	12
	beats above lower limit of WLP*						
0 Kp	1-5	1	**1.7**	4	**6.9**	2	**4**
	6-10	3	**5.1**	4	**6.9**	1	**2**
	11-15	1	**1.7**	3	**5.2**	6	**12**
	16-20	8	**13.6**	4	**6.9**	6	**12**
	>20	32	**54.2**	40	**69.0**	28	**56**
Total		**59**		**58**		**50**	

* Note: Lower limit of workload progression (i.e., highest HR at which an individual can receive a .5 Kp WL progression) determined by age and minute of progression (see Appendix B, Table B3).

APPENDIXES

APPENDIX A: PROTOCOLS

WL = Workload

Protocol A: Alters the computer logic to make it more difficult for a subject to receive a 1.0 kilopond (Kp) or 0.5 Kp workload progression (i.e., lower the minimum HR needed to receive a workload increase

Protocol B: Lengthens each of the three stages at which workload progression occurs by 1 minute, thereby allowing more time to achieve a steady state HR

Time (min)	Original	A	B
-	Initial	Initial	Initial
1	Warmup	Warmup	Warmup
2	Warmup	Warmup	Warmup
3	WL Progression	WL Progression	Steady-state
4	WL Progression	WL Progression	WL Progression
5	WL Progression	WL Progression	Steady-state
6	Steady-state	Steady-state	WL Progression
7	Steady-state	Steady-state	Steady-state
8	Steady-state	Steady-state	WL Progression
9	Steady-state	Steady-state	Steady-state
10	Steady-state	Steady-state	Steady-state
11	Steady-state	Steady-state	Steady-state
12	Optional	Optional	Steady-state
13	-	-	Steady-state
14	-	-	Steady-state

Note: Subjects must complete six minutes of steady-state workload. This steady-state phase begins as soon as there is no further workload progression. Steady-state heart rate is designated by a heart rate in the final minute within ± 3 beats of the previous minute. Test will be extended by one minute for individuals not in steady-state during the final minute (Original protocol and Protocol A).

APPENDIX B: INITIAL WORKLOAD SETTINGS/HEART RATE PARAMETERS

Table B1: Initial workload setting for females, in Kp.

	Weight									
	<54.88 kg (<121 lb.)		<63.95 kg (<141 lb.)		<73.02 kg (<161 lb.)		<82.09 kg (<181 lb.)		<226.76 kg (<500 lb.)	
Exercise History	Active	Inactive	Active	Inactive	Active	Inactive	Active	Inactive	Active	Inactive
Age										
17 - 35	1.0	1.0	1.5	1.0	1.5	1.0	2.0	1.5	2.0	2.0
36 - 50	1.0	1.0	1.5	1.0	1.5	1.0	2.0	1.5	2.0	1.5
51 - 62	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.0	1.5	1.0
63 - 70	1.0	0.5	1.0	0.5	1.0	1.0	1.5	1.0	1.5	1.0

Table B2: Initial workload settings for males, in Kp.

	Weight									
	<59.41 kg (<131 lb.)		<68.48 kg (<151 lb.)		<82.09 kg (<181 lb.)		<100.23 kg (<221 lb.)		<226.76 kg (<500 lb.)	
Exercise History	Active	Inactive	Active	Inactive	Active	Inactive	Active	Inactive	Active	Inactive
Age										
17 - 35	1.5	1.0	2.0	1.5	2.0	2.0	2.5	2.0	2.5	2.5
36 - 50	1.5	1.0	1.5	1.5	2.0	2.0	2.0	2.0	2.5	2.0
51 - 62	1.5	1.0	1.5	1.0	2.0	1.5	2.0	1.5	2.0	1.5
63 - 70	1.0	1.0	1.5	1.0	1.5	1.0	1.5	1.5	1.5	1.5

Table B3: Heart rate parameters for workload progression (Protocol B and Original)

	Workload Progression											
	+1 Kp			+0.5 Kp			0.0 Kp			Terminate Assessment		
Minute	**3**	**4**	**5**	**3**	**4**	**5**	**3**	**4**	**5**	**3**	**4**	**5**
Age												
17 - 30	<110	<110	<115	110-119	110-119	115-128	120-173	120-173	129-173			
31 - 40	<105	<105	<110	105-114	105-114	110-126	115-161	115-161	127-161	Invalid if		
41 - 50	<100	<100	<105	100-109	100-109	105-122	110-152	110-152	123-152	>85% of max.		
51 - 60	<100	<100	<105	100-109	100-109	105-120	110-144	110-144	121-144	heart rate		
61 - 70	<90	<90	<95	90-104	90-104	95-105	105-135	105-135	106-135			

Progression workload cycle changes*.

*Note: Heart rates used to determine workload progression are taken at the end of the minute. For example, minute 3 of the assessment is performed at the initial workload, with the heart rate at the end of minute 3 determining the workload progression for minute 4 using "Minute 3" workload progression column.

Table B4: Heart rate parameters for workload progression (Protocol A)

	Workload Progression											
	+1 Kp			+0.5 Kp			0.0 Kp			Terminate Assessment		
Minute	**3**	**4**	**5**	**3**	**4**	**5**	**3**	**4**	**5**	**3**	**4**	**5**
Age												
17 - 30	**<100**	**<100**	<115	**100-119**	**100-119**	115-128	120-173	120-173	129-173			
31 - 40	**<95**	**<95**	<110	**95-114**	**95-114**	110-126	115-161	115-161	127-161	Invalid if		
41 - 50	**<90**	**<90**	<105	**90-109**	**90-109**	105-122	110-152	110-152	123-152	>85% of max.		
51 - 60	**<90**	**<90**	<105	**90-109**	**90-109**	105-120	110-144	110-144	121-144	heart rate		
61 - 70	**<80**	**<80**	<95	**80-104**	**80-104**	95-105	105-135	105-135	106-135			

Progression workload cycle changes.

*Note: Heart rates used to determine workload progression are taken at the end of the minute. For example, minute 3 of the assessment is performed at the initial workload, with the heart rate at the end of minute 3 determining the workload progression for minute 4 using "Minute 3" workload progression column.

APPENDIX C: CYCLE ERGOMETRY ASSESSMENT BREAKDOWNS

Table C1: Brooks, Kelly, and Randolph AFBs combined cycle ergometry assessment breakdown

Brooks, Kelly, and Randolph AFBs Combined Assessment Results			
Test Result	**# of assessments**	**% of Total Assessments**	
Invalids	814	16.7	
Fail	515	10.5	
Pass	3554	72.8	
Total	4883		
Test Result	**# of Assessments**	**% of Total Invalids**	**% of Total Assessments**
Invalid #1	298	36.6	6.1
Invalid #2	58	7.1	1.2
Invalid #3	96	11.8	2.0
Invalid #4	2	0.2	0.04
Invalid #5	107	13.1	2.2
Invalid #6	9	1.1	0.2
Invalid #7	244	30.0	5.0
Totals:	814	100	16.7

Table C2: Brooks AFB cycle ergometry assessment breakdown

Brooks AFB		
Test Result	**# of assessments**	**% of total**
Invalid #1	26	4.9
Invalid #2	4	0.7
Invalid #3	14	2.6
Invalid #5	10	1.9
Invalid #6	0	0
Invalid #7	60	11.3
Fail	51	9.6
Pass	365	68.9
Total:	530	
Totals		
	# of assessments	**% of total**
Invalid	114	21.5
Pass	365	68.9
Fail	51	9.6
Total:	530	

Table C3: Kelly AFB cycle ergometry assessment breakdown

Kelly AFB		
Test Result	**# of assessments**	**% of total**
Invalid #1	156	7.4
Invalid #2	20	0.9
Invalid #3	34	1.6
Invalid #4	2	0.09
Invalid #5	53	2.5
Invalid #6	4	0.2
Invalid #7	74	3.5
Fail	244	11.5
Pass	1531	72.3
Total:	2118	
	Totals	
	# of assessments	**% of total**
Invalid	343	16.2
Pass	1531	72.3
Fail	244	11.5
Total:	2118	

Table C4: Lackland AFB cycle ergometry assessment breakdown

Lackland AFB Test Results			
Test Result	**# of assessments**	**% of total assessments**	
Invalids	289	13.2	
Fail	180	8.2	
Pass	1722	78.6	
Total:	2191		
Test Result	**# of assessments**	**% of total invalids**	**% of total assessments**
Invalid #1	101	47.9	4.6
Invalid #2	17	7.9	0.7
Invalid #3	24	17.8	1.1
Invalid #4	4	0.5	0.2
Invalid #5	8	9.8	0.4
Invalid #6	7	1.3	0.3
Invalid #7	128	14.6	5.8
Totals:	289		

Table C5: Patrick AFB cycle ergometry assessment breakdown

Patrick AFB Test Results			
Test Result	**# of assessments**	**% of total assessments**	
Invalids	445	18.8	
Fail	209	8.8	
Pass	1709	72.3	
Total:	2363		
Test Result	**# of assessments**	**% of total invalids**	**% of total assessments**
Invalid #1	216	48.5	9.1
Invalid #2	46	10.3	1.9
Invalid #3	113	25.4	4.8
Invalid #4	2	0.4	0.08
Invalid #5	22	4.9	0.9
Invalid #6	8	1.8	0.3
Invalid #7	38	8.5	1.6
Totals:	445		

Table C6: Randolph AFB cycle ergometry assessment breakdown

Randolph AFB		
Test Result	**# of assessments**	**% of total**
Invalid #1	116	5.2
Invalid #2	34	1.5
Invalid #3	48	2.1
Invalid #5	44	2
Invalid #6	5	0.2
Invalid #7	110	4.9
Fail	220	9.8
Pass	1658	74.2
Total:	2235	
Totals		
	# of assessments	**% of total**
Invalid	357	16
Pass	1658	74.2
Fail	220	9.8
Total:	2235	

APPENDIX D: MINUTE THREE WORKLOAD PROGRESSION OF CATEGORY 1 INVALID ASSESSMENTS

Table D1: Brooks AFB minute three workload progression of Category 1 Invalid assessments

	Brooks AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	2	0.25	6	33.3
.5 Kp	2	0.25	5	27.8
0 Kp	4	0.5	7	38.9
Total	8		18	

Table D2: Kelly AFB minute three workload progression of Category 1 Invalid assessments

	Kelly AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	4	17.4	41	38.3
.5 Kp	5	21.7	15	14
0 Kp	14	60.9	51	47.7
Total	23		107	

Table D3: Randolph AFB minute three workload progression of Category 1 Invalid assessments

	Randolph AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	8	22.2	30	34.5
.5 Kp	7	19.4	15	17.2
0 Kp	21	58.3	42	48.3
Total	36		87	

APPENDIX E: MINUTE FOUR WORKLOAD PROGRESSION OF CATEGORY 1 INVALID ASSESSMENTS

Table E1: Brooks AFB minute four workload progression of Category 1 Invalid assessments

	Brooks AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	2	11.8
.5 Kp	1	12.5	3	17.6
0 Kp	7	87.5	12	70.6
Total	8		17	

Table E2: Kelly AFB minute four workload progression of Category 1 Invalid assessments

	Kelly AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	7	6.9
.5 Kp	0	0	17	16.8
0 Kp	21	100	77	76.2
Total	21		101	

Table E3: Randolph AFB minute four workload progression of Category 1 Invalid assessments

	Randolph AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	1	2.9	2	2.4
.5 Kp	3	8.6	14	17.1
0 Kp	31	88.6	66	80.5
Total	35		82	

APPENDIX F: MINUTE FIVE WORKLOAD PROGRESSION OF CATEGORY 1 INVALID ASSESSMENTS

Table F1: Brooks AFB minute five workload progression of Category 1 Invalid assessments

	Brooks AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	0	0
.5 Kp	0	0	3	17.6
0 Kp	8	100	14	82.4
Total	8		17	

Table F2: Kelly AFB minute five workload progression of Category 1 Invalid assessments

	Kelly AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	2	2.1
.5 Kp	2	10	26	27.3
0 Kp	18	90	67	70.5
Total	20		95	

Table F3: Randolph AFB minute five workload progression of Category 1 Invalid assessments

	Randolph AFB			
	Females		Males	
workload progression	# of assessments	% of total	# of assessments	% of total
1 Kp	0	0	0	0
.5 Kp	6	18.2	31	37.8
0 Kp	27	81.8	51	62.2
Total	33		82	

APPENDIX G: HEART-RATE RESPONSE TO WORKLOAD PROGRESSION OF INDIVIDUALS WITH A CATEGORY 1 INVALID OUTCOME

Table G1: Brooks AFB heart-rate response to workload progression of individuals with a Category 1 Invalid outcome

Males and Females Combined							
		Minute 3		Minute 4		Minute 5	
work load progression (WLP)	beats below initial workload inc.	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	1-5	0		1	4	0	
	6-10	5	19.2	0		0	
	>10	3	11.5	1	4	0	
.5 Kp	1-5	4	15.4	0		0	
	6-10	3	11.5	4	16	0	
	>10	0		0		3	12
	beats above lower limit of WLP						
0 Kp	1-5	0		1	4	3	12
	6-10	0		4	16	4	16
	11-15	3	11.5	1	4	2	8
	16-20	2	7.7	1	4	2	8
	>20	6	23.1	12	48	11	44
Total		26		25		25	

Table G2: Kelly AFB heart-rate response to workload progression of individuals with a Category 1 Invalid outcome

Males and Females Combined							
		Minute 3		Minute 4		Minute 5	
work load progression (WLP)	beats below initial workload inc.	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	1-5	18	13.8	3	2.5	1	0.9
	6-10	11	8.5	2	1.6	1	0.9
	11-15	10	7.7	1	0.8	0	
	>15	6	4.6	1	0.8	0	
.5 Kp	1-5	7	5.4	5	4.1	0	
	6-10	13	10	12	9.8	1	0.9
	11-15	0		0		17	14.8
	>15	0		0		10	9
	beats above lower limit of WLP						
0 Kp	1-5	4	3.1	9	7.4	4	3.5
	6-10	4	3.1	14	11.5	8	7
	11-15	3	2.3	11	9	13	11.3
	16-20	12	9.2	8	6.6	13	11.3
	>20	42	32.3	56	45.9	47	40.9
Total		130		122		115	

Table G3: Randolph AFB heart-rate response to workload progression of individuals with a Category 1 Invalid outcome

Males and Females Combined							
		Minute 3		Minute 4		Minute 5	
work load progression (WLP)	beats below initial workload inc.	# of assessments	% of total	# of assessments	% of total	# of assessments	% of total
1 Kp	1-5	16	13	2	1.7	0	
	6-10	8	6.5	0		0	
	>10	14	11.4	1	0.9	0	
.5 Kp	1-5	7	5.7	4	3.4	1	0.9
	6-10	14	11.4	13	11.1	5	4.3
	>10	1	0.8	0		31	27
	beats above lower limit of WLP						
0 Kp	1-5	3	2.4	15	12.8	7	6.1
	6-10	7	5.7	10	8.5	9	7.8
	11-15	3	2.4	15	12.8	11	9.6
	16-20	4	3.3	4	3.4	9	6.1
	>20	46	37.4	53	45.3	42	36.5
Total		123		117		115	

APPENDIX H: FIRST AND SECOND RE-TEST DATA FOR INDIVIDUALS WITH AN INITIAL CATEGORY 1, 2, 3, 4, OR 6 INVALID ASSESSMENT

Table H1: Brooks AFB first and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Brooks AFB			
first re-test	**result**	**# of assessments**	**percentage**
	Pass	14	66.7
	Fail	4	19
	Invalid	3	14.3
	Total	21	
second re-test	Pass	1	100
	Fail	0	0
	Invalid	0	0
	Total	1	

Table H2: Kelly AFB first and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Kelly AFB			
first re-test	**result**	**# of assessments**	**percentage**
	Pass	66	52
	Fail	38	30
	Invalid	23	18
	Total	127	
second re-test	Pass	19	55.9
	Fail	8	23.5
	Invalid	7	20.6
	Total	34	

Table H3: Lackland AFB first and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Lackland AFB			
first re-test	**result**	**# of assessments**	**percentage**
	Pass	31	50.8
	Fail	20	32.8
	Invalid	10	16.4
	Total	61	
second re-test	Pass	3	30
	Fail	2	20
	Invalid	5	50
	Total	10	

Table H4: Patrick AFB first and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Patrick AFB			
first re-test	**result**	**# of assessments**	**percentage**
	Pass	108	57.8
	Fail	25	13.4
	Invalid	54	28.9
	Total	187	
second re-test	Pass	14	36.8
	Fail	7	18.4
	Invalid	17	44.7
	Total	38	

Table H5: Randolph AFB first and second re-test data for individuals with an initial Category 1, 2, 3, 4, or 6 Invalid assessment

Randolph AFB			
first re-test	**result**	**# of assessments**	**percentage**
	Pass	61	54.5
	Fail	24	22.6
	Invalid	21	19.8
	Total	106	
second re-test	Pass	7	63.6
	Fail	4	36.4
	Invalid	0	0
	Total	11	

LIST OF SYMBOLS, ABBREVIATIONS, AND ACRONYMS

AF 2000	cycle ergometry software
bpm	beats per minute
CE	Cycle Ergometry
FAM	Fitness Assessment Monitor
FitSoft 2.0	cycle ergometry software
HR	heart rate
HRm	heart rate85% of maximum (220 minus age times .85)
Kp	kilopond
Protocol A	a reduction of 10 beats per minute to the threshold for workload progression by the CE computer logic
Protocol B	lengthens each of the three stages at which workload progression occurs by one minute
RPE	Rating of Perceived Exertion
$VO_{2\,max}$	maximal oxygen consumption
WL	workload
WLP	workload progression